Physics and Detector Study of proposed 1 TeV Parameters

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Reporting work of the

SB2009 Physics & Detectors Study Group

Motivation for TeV Upgrade

Independent of the results from the first few years of running there are several reasons for an energy upgrade to 1 TeV:

- higher sensitivities for anomalous gauge boson couplings,
- measurement of the Higgs boson self coupling,
- the coupling of the Higgs to the top quark,
- production thresholds for new massive particles,
- exploration of extra spatial dimensions, and
- other new physics.

Parameters for the Linear Collider, Update November 20, 2006

Requirements of the TeV Upgrade

- The luminosity and reliability of the machine should allow the collection of order of 1 ab^{-1} (equivalent at 1 TeV) in about 3 to 4 years.
  - note that point cross sections fall with energy
  - even more would be better
- The machine should have the capability for running at any energy value for continuum measurements and for threshold scans up to the maximum energy with the design luminosity (√s scaling assumed).
- Beam energy stability and accuracy should be as stated for the baseline machine.

Parameters for the Linear Collider, Update November 20, 2006

Detailed Baseline Design

- Significant time is needed to generate simulated events and analyze them for the DBD next year.

  - $e^+ e^- \rightarrow \nu \nu H$: Higgs branching ratio @1TeV
    - Test detector performance for simplest context
  - $e^+ e^- \rightarrow t t H$: Top Yukawa coupling @1TeV
    - Detector performance for complex (8 jet) events
  - $e^+ e^- \rightarrow W^+ W^-$: In-situ polarization measurement @1TeV
    - Detector performance for high energy jet
    - Capability of forward detector elements

- For this, collider parameters for the 1 TeV upgrade must be fixed <u>now</u> for the physics studies, with understanding that GDE final optimization may change the parameters

New parameters

- We have been studying new 1 TeV parameter sets (constrained to 300 MW)
  - 5% beamstrahlung
  - 10% beamstrahlung
- Initially sets with larger beamstrahlung provides much higher luminosity, but also wider pair distributions
  - are the backgrounds tolerable for physics?
  - can pair distributions be tightened?

First Strawman Parameters (300 MW, 5-10% BS)

			Straw-man TeV	
			A0	B0
			300MW 5%BS	300MW 10%BS
Ecm	GeV		1000	1000
Ngamma			1.4	1.7
deltaB			5.3%	10.9%
Lgeo			1.89E+34	3.16E+34
L (formula)			**2.89E+34**	**4.82E+34**
Simulation (noTF)				
Ngamma			1.445	1.762
deltaB	%		5.277	9.905
L			2.825E+34	4.74E+34
pT(E=50MeV) by CAIN	MeV/c		8.58	11.14
Simulation (TF)				
Ngamma			1.437	1.752
deltaB	%		5.182	9.826
L			3.34E+34	5.60E+34
pT(E=50MeV) by CAIN	MeV/c		8.67	11.14

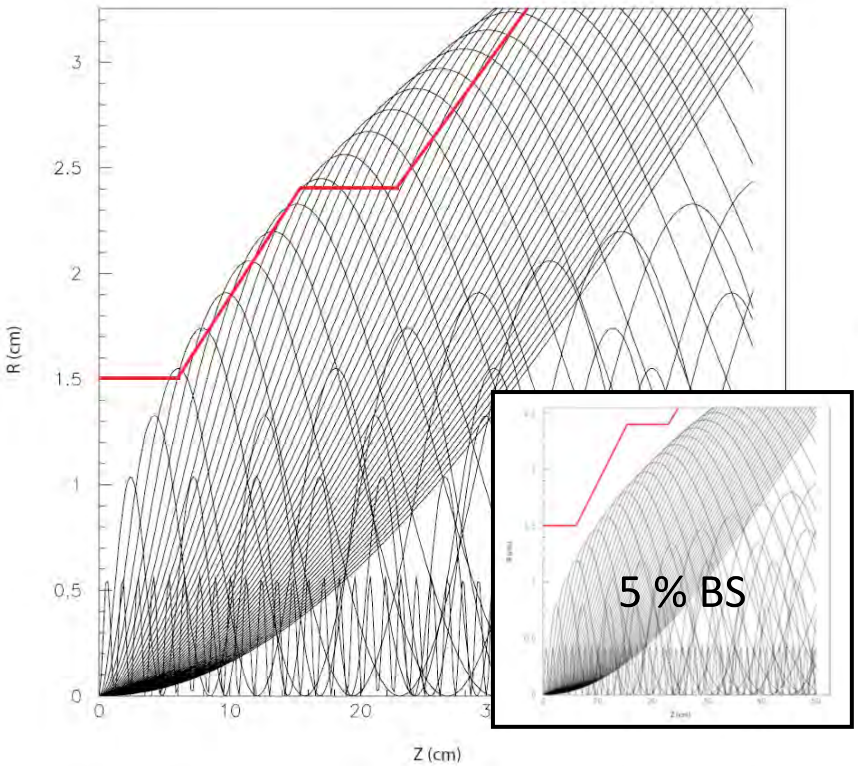
Detector Impacts

- Two aspects of the detector are particularly sensitive to the machine parameters
  - vertex detector - i.e. the inner radius
  - forward detection in the LumiCal

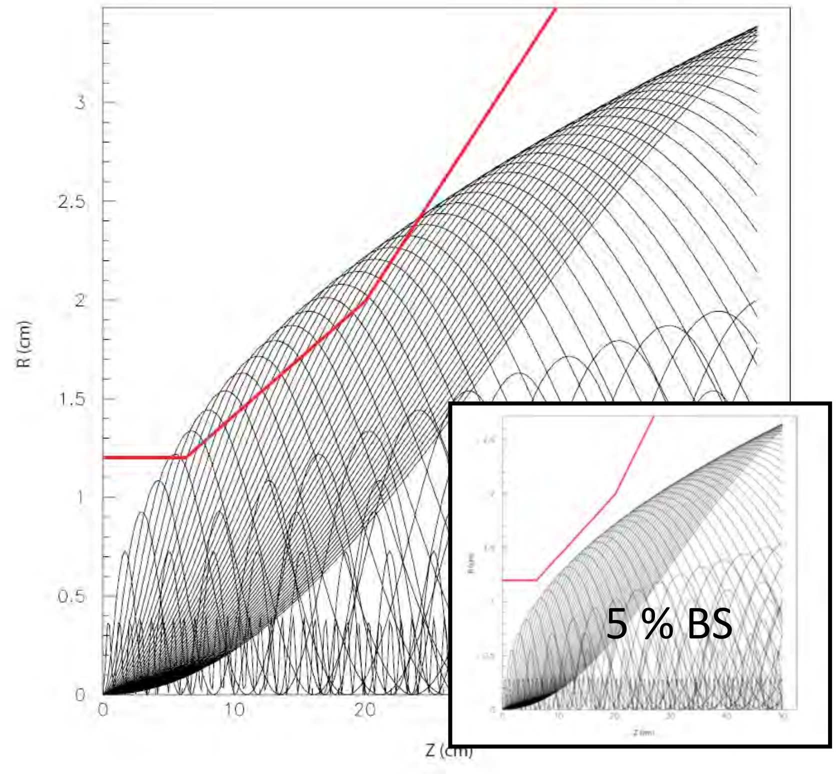
Initial proposed set (B0) with 10 % BS

500 GeV Beampipe design too aggressive

ILD Beampipe with 3.5 Tesla



SiD Beampipe with 5 Tesla



Takashi Maruyama

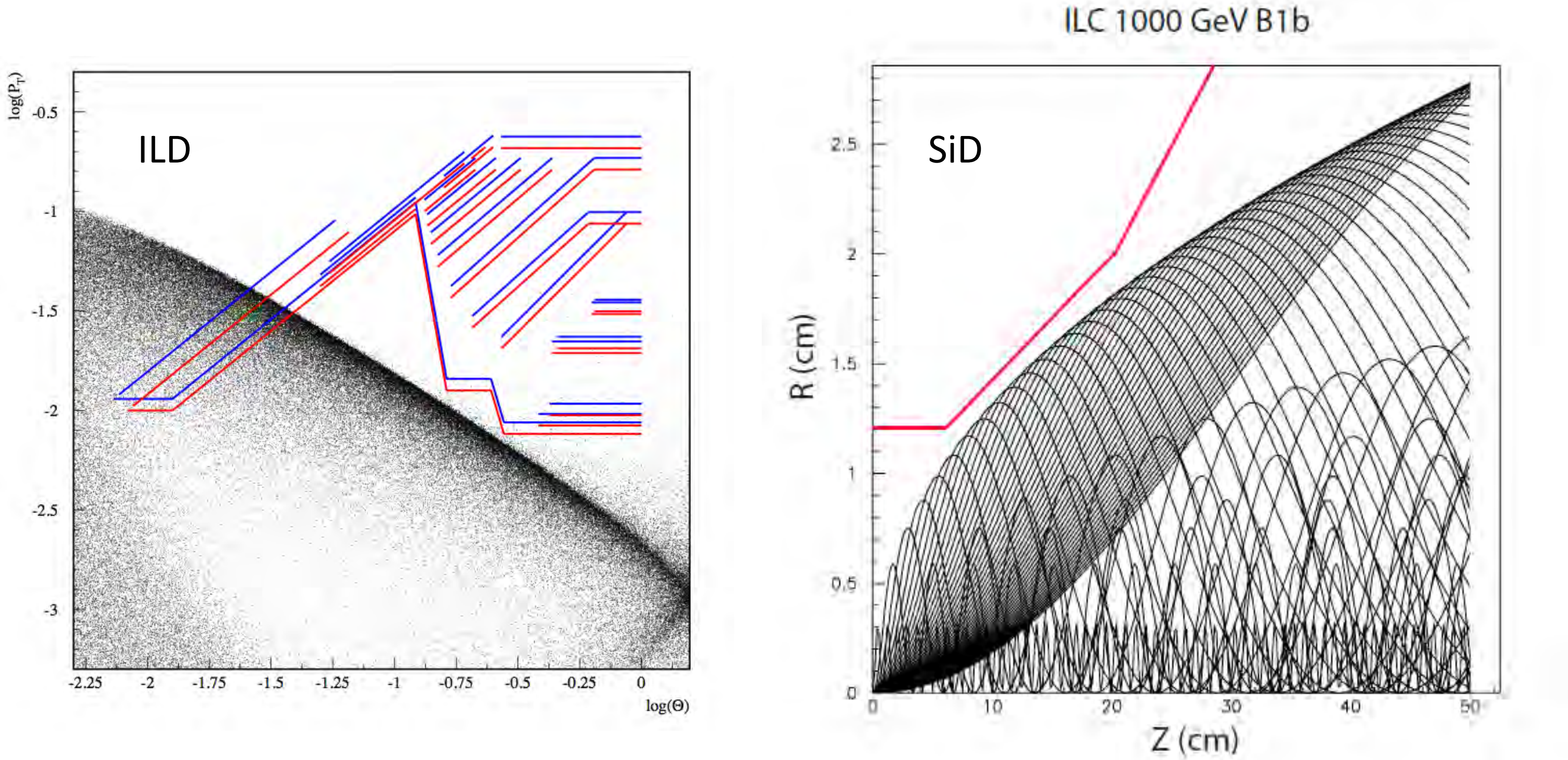
Similar results found independently by M. Berggren

Question

- Question posed by physics and detector colleagues:
  - Would it be possible to produce a set of parameters with 10% BS and the same higher luminosity, but with less divergence of the pairs cone?

		500GeV Reference		Straw-man TeV					
				A0	B0	A1	B1	B1a	B1b
		no TF	TF	300MW 5%BS	300MW 10%BS				
Ecm	GeV	500	500	1000	1000	1000	1000	1000	1000
Ngamma		1.7	1.7	1.4	1.7	1.4	1.7	1.9	2.0
deltaB		3.7%	3.7%	5.3%	10.9%	5.3%	10.9%	10.2%	10.2%
Lgeo		7.51E+33	1.16E+34	1.89E+34	3.16E+34	1.89E+34	3.15E+34	2.91E+34	2.86E+34
L (formula)		1.47E+34	1.75E+34	2.89E+34	4.82E+34	2.90E+34	4.82E+34	4.61E+34	4.65E+34
Simulation (noTF)									
Ngamma				1.445	1.762	1.446	1.758		
deltaB	%			5.277	9.905	5.288	9.899		
L				2.825E+34	4.74E+34	2.84E+34	4.75E+34		
L(1%)	%			61.5	48.4	61.2	48.5		
pT(E=50MeV) by CAIN	MeV/c			8.58	11.14	8.27	10.62		
simulation (TF)									
Ngamma				1.437	1.752	1.448	1.757	1.939	2.054
deltaB	%			5.182	9.826	5.265	9.85	9.603	9.796
L				3.34E+34	5.60E+34	3.35E+34	5.61E+34	5.50E+34	5.56E+34
L(1%)	%			60.8	48.1	60.5	47.8	46.65	45.553
pT(E=50MeV) by CAIN	MeV/c			8.67	11.14	8.18	10.6	9.3	8.8

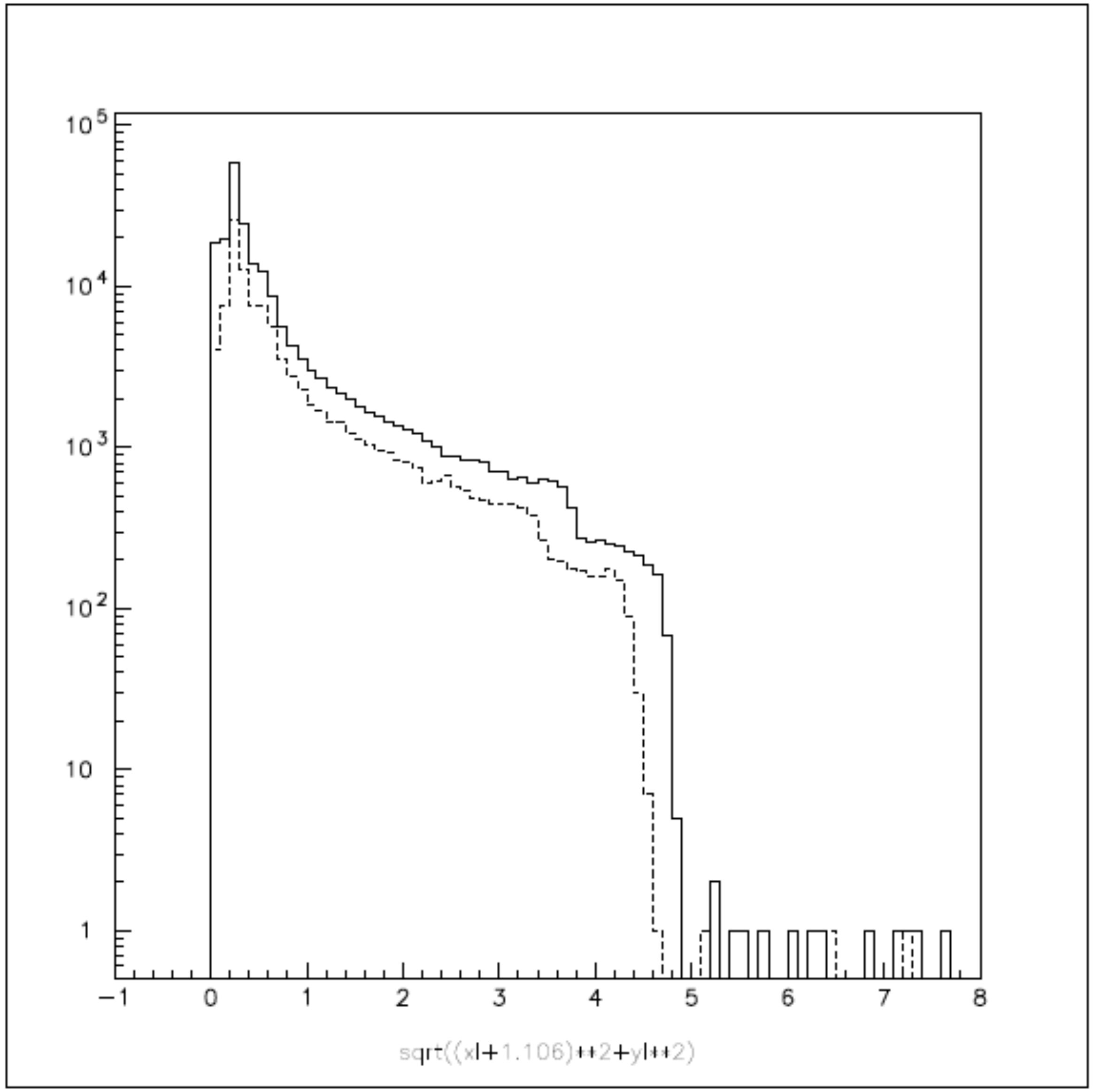
B1b pairs at Beampipe



- Pair edge is typically 1.8 - 2 mm away from the beam pipe to be comfortable.
- Pair edge of B1b is about 1 mm from the beam pipe.
  - For DBD, B1b should work without changing the beam pipe.

Pair distribution at face of Lumical

- SiD pair radial distribution at the face of Lumical.
- Solid line is ILC 1000 GeV B1b TF.
- Dash line is ILC 500 GeV SB2009 TF.
- Beampipe radius inside the Lumical is 6 cm.
- Pair edge gets larger by ~4 mm at 1 TeV, but it still has 1 cm clearance.
    - Takashi Maruyama



1 TeV Plan for DBD

- CONCLUSION - Beamstrahlung is acceptable for 1 TeV B1b parameters.
- We plan to use the B1b parameters (10% w/TF) for the DBD simulation.
  - Instantaneous luminosity is high (5.6 x 10^{34})
  - Beampipe does not need to change from 500 GeV
  - Luminosity spectrum and pairs are manageable
  - We know GDE will continue work to optimize, but we expect the final design not to be too different from this choice.

		500GeV Reference		Straw-man TeV							
				A0	B0	C0	A1	B1	B1a	B1b	C1
		no TF	TF	300MW 5%BS	300MW 10%BS	LongBunch					LongBunch
Ecm	GeV	500	500	1000	1000	1000	1000	1000	1000	1000	1000
gamma		4.89E+05	4.89E+05	9.78E+05	9.78E+05	9.78E+05	9.78E+05	9.78E+05	9.78E+05	9.78E+05	9.78E+05
N	e10	2.0	2.0	2.0	2.0	2.0	1.737	1.737	1.737	1.737	1.737
frep	Hz	5.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Nb		1312	1312	2280	2280	2280	2625	2625	2625	2625	2625
PB	MW	10.5	10.5	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
sigz	mm	0.3	0.3	0.25	0.15	0.3	0.25	0.15	0.2	0.225	0.3
enx	m	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
eny	m	3.5E-08	3.5E-08	3.0E-08	3.0E-08	3.0E-08	3.0E-08	3.0E-08	3.0E-08	3.0E-08	3.0E-08
betax	mm	11.0	11.0	30.0	18.0	11.0	22.6	13.6	12.0	11.0	8.6
betay	mm	0.48	0.20	0.25	0.15	0.30	0.25	0.15	0.20	0.23	0.30
sigx	nm	474.2	474.2	553.7	428.9	335.3	480.6	372.8	350.2	335.3	296.5
sigy	nm	5.86	3.78	2.77	2.14	3.03	2.77	2.14	2.48	2.63	3.03
theta_x	ur	43.1	43.1	18.5	23.8	30.5	21.3	27.4	29.2	30.5	34.5
theta_y	ur	12.2	18.9	11.1	14.3	10.1	11.1	14.3	12.4	11.7	10.1
Dx		0.30	0.30	0.09	0.09	0.30	0.11	0.11	0.16	0.20	0.34
Dy		24.6	38.2	18.7	18.7	33.7	18.7	18.7	22.9	25.4	33.0
Upsilon		0.062	0.062	0.128	0.274	0.175	0.128	0.274	0.218	0.203	0.171
Ngamma		1.7	1.7	1.4	1.7	2.3	1.4	1.7	1.9	2.0	2.3
deltaB		3.7%	3.7%	5.3%	10.9%	10.7%	5.3%	10.9%	10.2%	10.2%	10.4%
HDx		1.1	1.1	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.2
HDy		6.1	2.8	3.5	3.5	4.5	3.5	3.5	3.9	4.0	4.5
HDy		2.0	1.5	1.5	1.5	1.8	1.5	1.5	1.6	1.6	1.8
Lgeo		7.51E+33	1.16E+34	1.89E+34	3.16E+34	2.85E+34	1.89E+34	3.15E+34	2.91E+34	2.86E+34	2.80E+34
L (formula)		1.47E+34	1.75E+34	2.89E+34	4.82E+34	5.08E+34	2.90E+34	4.82E+34	4.81E+34	4.65E+34	5.05E+34
Simulation (noTF)				A0	B0	C0	A1	B1	B1a	B1b	C1
Ngamma				1.445	1.762	2.475	1.446	1.758			2.453
deltaB	%			5.277	9.905	10.909	5.288	9.899			10.735
L				2.825E+34	4.74E+34	4.87E+34	2.84E+34	4.75E+34			4.84E+34
L(1%)	%			61.5	48.4	42.7	61.2	48.5			42.9
pT(E=50MeV) by CAIN	MeV/c			8.58	11.14	8.575	8.27	10.62			8.08
simulation (TF)											
Ngamma				1.437	1.752	2.494	1.448	1.757	1.939	2.054	2.476
deltaB	%			5.182	9.826	11.05	5.265	9.85	9.603	9.796	10.91
L				3.34E+34	5.60E+34	5.86E+34	3.35E+34	5.61E+34	5.50E+34	5.56E+34	5.80E+34
L(1%)	%			60.8	48.1	41.8	60.5	47.8	46.65	45.553	42.1
pT(E=50MeV) by CAIN	MeV/c			8.67	11.14	8.677	8.18	10.6	9.3	8.8	8.176
L(TR)/L(no)				1.195	1.185	1.203	1.182	1.181	#DIV/0!	#DIV/0!	1.200